REPORT ON THE PADI-BORER.

MY attention was called to this subject, by a letter dated the 1st of January, 1887, that was forwarded to me by H. M.'s Assistant Resident of Pérak from Dr. LEECH, the Collector and Magistrate of the Krian District, in which he says :—

" With this letter I have the honour to forward you a bottle
" containing some specimens of a maggot which is at present
" playing havoc with the padi crop here. This is the third
" season I have heard of its attacks, and each year has been
" worse than the preceding one. The time, it appears, is just
" as the ear is beginning to form.

" Many (maggots) are found in one stalk, the whole inside
" of which becomes brown and rotten. I have seen acres of
" padi attacked in the way, with the stalks and ears complete,
" but without a single grain of rice in them. It appears that it
" makes no difference, whether the land is dry or wet. I have
" not been able to ascertain what sort of insect produces
" these maggots.

" If any method of destroying them could be got, it would
" be a great blessing to the people of this district, as the
" ravages committed by this maggot, far exceed those of the
" rats or pigs—the other enemies of the padi crop.

" Perhaps the Curator of the Museum or H. M.'s Resident
" may know something of the habits of this pest, and suggest
" some means of destroying it."

On the 12th January, I suggested the burning of the straw after the harvest, and Dr. LEECH sent out a Malay notice recommending this course to the cultivators in his district.

Since January, I have visited the padi-fields and have procured specimens of the caterpillars, which I have kept, and have bred from them the perfect insects. The results of these observations I will now proceed to detail, beginning with the description of the various stages of the Padi-Borer Moth.

Description.

Chilo species affin. *C. Oryzæellus* of Riley.

The egg is oval shaped and white, faintly tinted with green. It has a finely pitted surface with some irregular, longitudinal creases. They are laid in masses of thirty or more together, in a slanting, overlapping, double, treble, or more extended series, and are firmly cemented together, and to the leaves on which they are laid. The egg is about $\frac{3}{100}$th inch long by $\frac{15}{1000}$th inch wide.

Larva.—Head dark brown, polished, furnished with a few stiff brownish hairs, a median yellowish line. Cervical shield varies from light to dark brown, with a median yellowish line. Colour of body pale yellowish white, slightly transparent, marked with five rather indistinct, pale purplish stripes, of which those bordering the stigmata are scarcely half as broad as the other three. The piliferous spots are oval, yellowish coloured and polished, stigmata small, transversely oval, brown, the last pair twice as large as the others, these latter are sometimes pale centred. Anal plate yellowish, polished, furnished with a row of three hairs upon each side and two near middle, it is marked with a few purplish spots.

Length $\frac{7}{8}$th to $1\frac{1}{10}$th inch. Diameter $\frac{1}{10}$th to $\frac{3}{20}$th inch.

Pupa.—Colour pale yellowish brown, with five brown longitudinal stripes. As it nears maturity it assumes a dark brown colour, wing cases paler and with a pearly lustre. Head bent forward, its front somewhat pointed. Thorax with very fine transverse striæ. Abdominal joints, armed dorsally, near their anterior margin, with numerous very minute brown thorns. Stigmata projecting. Tip of last joint conical, with a longitudinal lateral impression; expanding dorsally into two flattened projections, each being divided into two broad teeth. There are also two projections from the lower surface of the last joint, one on each side of the longitudinal impression. Length $\frac{3}{10}$th to $\frac{6}{10}$th inch, and diameter $\frac{3}{40}$th to $\frac{1}{10}$th inch.

Imago.—Male, above, general colour pale ochraceous. Anterior wings, with an irregular oblique fuscous fascia, from about the middle of inner margin to near the apex of wing. Costal and posterior margins ochraceous, fringe golden. A marginal line of seven small brown spots and a submarginal line of shining golden brown spots, along the posterior margin, but curving away from the apex. Some of these shining spots are also scattered over the oblique fuscous fascia, more thickly near the end of the cell.

Hind wings paler and unmarked. Beneath, anterior wings dull yellowish, sometimes sullied with dirty brown. Hind wings the same, but only slightly tinged with brown on the costal region. Body and legs same colour as palest part of wings.

Labial palpi bushy and slightly broadened at tip, horizontal, nearly as long as head and thorax together, a few dark scales and hairs intermixed with the paler ones. Maxillary palpi prominent, with only a few dark scales. Eyes black. Antennæ more than half the length of the costal margin of the anterior wings, filiform, clothed with pale ochraceous scales. Expanse $\frac{7}{10}$th to $\frac{8}{10}$th inch, and body $\frac{3}{10}$th to $\frac{4}{10}$th inch long.

The female differs in being duller in colour and in the fascia on anterior wings being very indistinct. Beneath dull pale ochraceous. Labial palpi more bushy and larger than in the male. Expanse $\frac{19}{20}$th of an inch, and body $\frac{1}{2}$ inch long.

This insect evidently belongs to the genus *Chilo* of ZINCKEN-SOMMER, and may not be specifically distinct from *C. Oryzœellus* of RILEY, as the differences noticeable in it may be only of a variatal character.

A comparison with the type specimen would be necessary to determine this point. *C. Oryzœellus* is an insect of much the same habits as ours, and found in North America.

Natural History and Habits.

The eggs are laid in white irregular shaped masses, which may measure as much as $\frac{1}{4}$ inch in length, by nearly $\frac{1}{10}$ inch in width, on the leaves of the padi plant. The eggs after a few days become greyish, from the formation of the young caterpillars inside them. In the case of one female that I reared, eleven such masses were deposited in one night, and seven the next. One mass that I counted under the miscroscope, contained 39 eggs, so that it would be safe to say, that one female will lay as many as 600 eggs.

As there was not much choice possible in this case, nothing could be gleaned as to the part of the plant which would be selected, in a state of nature, by the female to deposit her eggs on, except that no eggs are deposited on the stem of the plant. Judging from the position of the young caterpillars, the part selected is at the junction of a young leaf with the stalk.

From this point, as soon as the eggs are hatched, the young caterpillars eat their way into the tender shoot or into the midrib of the leaf in the case of the first brood, as will be mentioned further on. On exhausting the supply of food in the growing shoot, they bore out and re-enter the stalk lower down.

The caterpillar makes a nearly circular hole where it enters a stalk, which it closes up from the inside, with fæcal pellets and some fine white silk, and sometimes with the latter substance alone. When a caterpillar has eaten all the inner lining of one joint, or as much of it as it fancies, it either bores out again, and enters another joint, usually lower down the stalk, or it bores through the substance of the joint itself. This latter method of seeking for a fresh supply of food I have seen adopted on several occasions, both in the straws picked in the field and also in those I have kept for purposes of observation. Sometimes it is the bottom of a joint, and sometimes the top which is thus perforated.

The stalks are usually more eaten near the joints than elsewhere, and often the film remaining is so thin, that the stalk breaks short off. When the caterpillar is short of food, it will feed on the inner lining of the leafstalks. This has happened in my breeding experiments, and I have also noticed it in the fields.

In the first brood of the season, the food of the caterpillar is principally supplied by the growing shoot, and the interior of the midrib of the leaves and leafstalks. This first brood reaches maturity before any appreciable amount of hollow stalk is formed by the padi, and hence this change, in what may be considered its normal habits, is necessary, to adapt itself to its environment. The pupæ of this first brood are nearly always found in the leafstalks. In subsequent broods they are generally found in the inside of the stalk, sometimes above the hole of entrance and sometimes beneath it. The pupæ are usually more or less enclosed in a fine white web, and the head is, in all cases that have come under my observation, uppermost.

The larvæ are able to progress with nearly equal facility either backwards or forwards, but they are not active at any time, and when disturbed generally remain quiescent.

In a single stool of young padi, I found no less than 20 caterpillars. This plant was found growing by itself in Taiping and not near any padi fields, probably the nearest being more than two or three miles away. This seems to show, either that the moths take long flights, or that some wild plant serves as food for the caterpillar as well as padi.

When kept in confinement, the moths sit quite still all day, and by preference on the earth at the bottom of the breeding cage. It seems, therefore, probable that they sit usually on the dead leaves of the padi during the day time, and as their colour so nearly assimilates to it, this would be a position of great security. I have hunted over a field of padi for them, but without success, though the straw was full of full grown caterpillars and also of minute ones, and there must have been many of the moths about. In the day time it is difficult to get them to fly even when touched, but at night they are fairly active and seem to be able to fly well.

The female begins laying her eggs on the second night after coming out of the chrysalis, and they hatch out on the fifth day, the female dying in about seven days. The eggs seem to be all laid on the second and third night. The males in a state of captivity, only live from three to four days.

The antennæ of the moth are carried, laid back on the wings, and have to be looked closely for, or they will pass unnoticed.

Usually only one caterpillar is formed in a stalk of padi, but I have found as many as five on one or two occasions. Judging from the breeding experiments, several stalks may be required to afford sufficient food for the support of a single carterpillar.

Number of Broods.

On the 29th April, or more than six weeks after the harvest in this district, I found in the padi stalks several minute caterpillars as well as many more advanced, in fact they ranged from one-eighth of an inch to full grown ones. I also examined a young stool of padi and found in it four or five chrysalides. This clearly shows that a brood has time to mature before the padi has begun to throw up stalks, and taken with the presence of the caterpillars in all stages in the straw after the harvest, it is probable that three broods arive at maturity before the harvest, and that there are three more between then and the next planting, making about six in the year. That would be two months for each generation.

Natural Enemies.

Out of one lot of four grubs raised by me, three were destroyed by the larva of some other insect, and on an examination of a padi field one day, I found no less than five live pupæ and three empty cases of the same parasite, and not one single live pupa of the rice-borer, and only two or three empty cases. This parasitic larva is, therefore, one of the most powerful aids in ckecking the increase of these destructive pests, and it would seem that, without its help, the cultivation of padi in the Malay fashion would be quite impossible.

The parasitic insect, to which we are so much indebted, is a fly, in appearance much like a common house-fly; and its larva is a small white maggot, which is either laid in or on the body of the rice-borer, and which lives inside its body and soon destroys it.

Description.

Order, Diptera.	Family, Muscidœ.
Tachinariœ.	Genus and Species, (?)

Larva.—Milk white and semi-transparent. Skin shiny, the anterior and posterior quarter of each segment armed with minute brown thorns. Cylindrical, with the head not distinct from body; which is abruptly terminated posteriorly and conically anteriorly. On last segment a pair of warm brown stigmata. Mouth furnished with two black hook-like organs. Length of a full grown one, that I extracted from a dead padi-borer, $\frac{1}{2}$ inch, and diameter $\frac{1}{8}$th inch.

The thorns on the body of the maggot are evidently the means of locomotion inside the body of its host. In two padi-borers that I opened, the head of the maggot was towards the tail of its host. The larva is very difficult to kill; withstanding immersion in spirits for a period of two and a half hours.

Pupa.—Cylindrical, with rounded ends, of a warm brown colour. Length $\frac{9}{20}$th inch, and $\frac{5}{40}$th inch in diameter.

The insect continues in the pupa state from twelve to thirteen days.

Imago.—Head silvery grey with red brown eyes and black bristles. Antennæ with three joints, of which the last is the largest, a single long hair projecting from near base of third joint. Palpi consist of a single joint. Above, thorax black with grey stripe on each side and two others on the dorsal aspect. Scutellum grey except central portion, which is black. Abdomen black, with three silvery transverse stripes, partly interrupted on the median line. Hairs on abdomen black, conspicuous on the two last segments. Wings hyaline, iridescent, unmarked; halteres covered by large milk white scales. Beneath wholly black, except three faint grey transverse stripes on abdomen. Legs black. Length $\frac{7}{20}$th inch and $\frac{6}{10}$th inch across wings; the female is a little larger.

In confinement these flies live from four to five days. I have not been able to observe the method in which the fly gets at the padi-borer to lay its egg, or young, as the case may be; but it is probably when the latter leaves one joint of the stalk in search of more food that the fly effects its purpose.

Effects on the Crop.

As I have already stated, the first brood of caterpillars matures before the rice has made any stalk, and that its food consists of the midribs of the leaves and the growing shoot. This leads to the death of those young shoots which are infested by the borer. The next brood which pass their lives inside the stalk are those which cause the abortive ears of rice, and are, therefore, the most destructive to the crop. Though the first brood by killing the growing shoots of course do very considerable damage.

In the letter I have already quoted, Dr. LEECH has given his experience in the Krian district, and from what I have seen in Larut, nearly as much loss has been inflicted on the crops here.

Preventive Measures.

By the Malay way of harvesting, only the ears of the padi plant are cut, and the straw is left standing in the fields until the next planting season comes round. Hence all the caterpillars and chrysalides have an opportunity of maturing and continuing the species to the next season's crop.

The perpetuation of the race from one season to another is undoubtedly carried on through the self-sown rice and the lateral shoots of the old plants, though it is possible that some large stemmed grass may play a minor part in the matter.

I found, six weeks after the harvest, in this district, that the straw was swarming with caterpillars of all ages; and I was informed by the Malays, that the shoots of the old plants and the self-sown rice, would continue alive until the land was broken up again for the next planting; so that food is available throughout the year for the sustenance of the successive broods of caterpillars.

A consideration of these facts, as well as of the life history of the borer, leads to the conclusion that the method which is most likely to keep down its numbers, is to destroy the straw by fire as soon after the harvest as possible, and to take any measures that will tend to kill or prevent the growth of the self-sown rice, between the harvest and the next year's sowing. With the efficient help which is given by the parasitic fly I have already mentioned, there should not be much difficulty in comparatively freeing the padi fields of this very destructive scourge, if the cultivators could only be induced to take a little united action.

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ADDENDA.

Since the above was written, further research has brought to light another insect associated with the one I have already described, and of almost the same habits and general appearance. In fact so close is the resemblance that it was not until the change from the larva state took place, that I noticed any difference; except that the caterpillar was nearly uniform pale brownish pink and without the five purplish longitudinal stripes. This was unfortunate, as I did not make a close examination or take down a description of this stage of the borer.

The other stages of its life were, however, recorded, and are as follows:—

Pupa.—Colour pale brown, darker at head, tail and margins of joints, with a white bloom over the whole. Head only slightly bent forward, its front somewhat rounded. Eyes projecting, black. Thorax minutely pitted. Abdominal joints also minutely pitted and with dark brown depressed spots scattered irregularly over them, more thickly on their anterior halves. Stigmata projecting. Tip of last joint rounded with a small projection which is produced into four sharp teeth, the two lower ones pointing downwards and the upper ones backwards.

Length $\frac{6}{10}$th inch, and diameter nearly $\frac{2}{10}$th inch.

Imago.—Above, anterior wings pale yellowish-brown, with a violet-brown stripe from insertion of wing to about the middle of the posterior margin, along the median nervure. This stripe broadens towards the posterior margin, which is shaded with the same colour. A distant series of five small brown sub-marginal spots along the posterior margin, and a spot near median nervure opposite end of cell. Tinge shining pale golden brown.

Posterior wings silvery white slightly tinted with yellow.

Beneath, pale silvery yellowish brown : hind wings paler than the anterior ones.

Head much depressed, eyes dark brown, invisible from above, thorax clothed with long hairs, ochraceous towards neck and paler towards abdomen. Thorax beneath densely clothed with long hair, as are also the two upper joints of the legs. Antennæ one quarter the length of costal margin, filiform, yellowish-brown, clothed with a few short hairs. Labial palpi short, scarcely projecting beyond face. Last joint short and clothed with close, short scales. The scales on the remainder of palpi bushy, some dark ones mixed with the paler.

Expanse of wings 1$\frac{2}{10}$th inch, length $\frac{6}{10}$th inch.

This moth appears to have the same habits as the other species ; but it is not nearly so numerous in the Larut padi fields. I have only met with two examples out of the many borers I have raised, though possibly in other parts of the country it may be the more plentiful and destructive of the two.

It does not seem to remain in the chrysalis longer than the other, nor is its life in the perfect state any more extended, so that any measures that would be efficacious in preventing the spread of the one would be equally applicable to the other.

L. W., JR.